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A PLANNING GUIDE FOR VOCATIONAL-INDUSTRIAL AND VOCATIONAL-TECHNICAL BUILDING FACILITIES FOR COMPREHENSIVE HIGH SCHOOLS, NUMBER 18.

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THIS BOOKLET IS INTENDED AS A GUIDE FOR THOSE RESPONSIBLE FOR PLANNING VOCATIONAL HIGH SCHOOL FACILITIES. DISCUSSION OF TYPES OF INDUSTRIAL EDUCATION, PLANNING PROCEDURES, AND GENERAL CONSIDERATIONS ARE INCLUDED AND INFORMATION IS GIVEN ON--(1) SIZES, SHAPES, AND NUMBER OF SHOPS, (2) BUILDING FLEXIBILITY, (3) LAYOUT OF FLOOR SPACE, (4) SERVICES IN SHOPS, (5) AUXILIARY FACILITIES, (6) FLOORS, (7) ACOUSTICS, (8) PROVISIONS FOR VISUAL COMFORT AND EFFICIENCY, AND (9) HEATING AND VENTILATION. TABLES AND RECOMMENDATIONS FOLLOW DISCUSSIONS WHEN APPROPRIATE, AND A BIBLIOGRAPHY OF RELEVANT LITERATURE IS PROVIDED. (JT)

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THE UNIVERSITY OF THE STATE OF NEW YORK
THE STATE EDUCATION DEPARTMENT
DIVISION OF EDUCATIONAL FACILITIES PLANNING
ALBANY, NEW YORK 12224

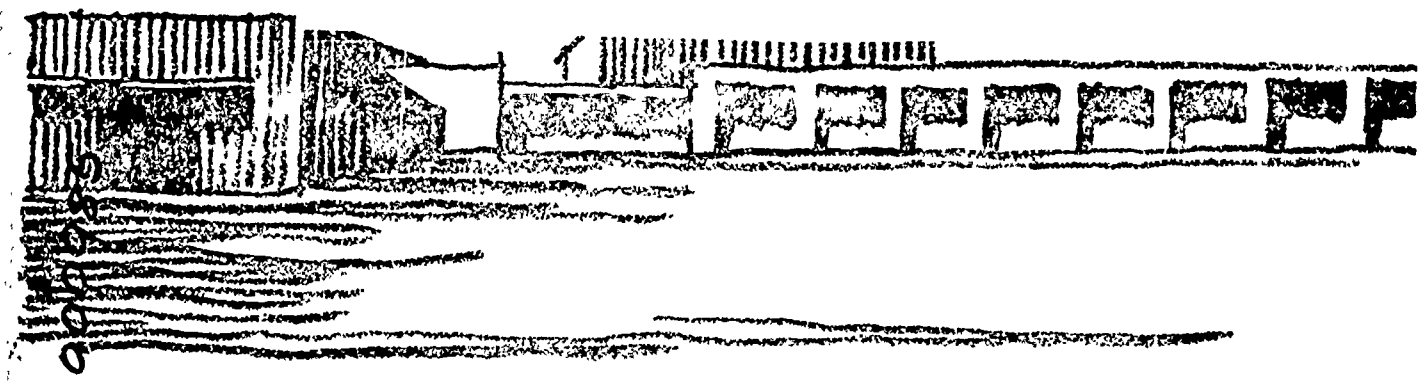
A Planning Guide

for

Vocational-Industrial and Vocational-Technical Building Facilities

for

Comprehensive High Schools



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INTRODUCTION

This guide is for the use of those who have responsibility for planning vocational-industrial and vocational-technical education building facilities with pertinent facts considered by specialists as basic in the determination of desirable practices.

The use of the term "standard" has been avoided because that word has frequently carried a cannotation of relative rigidity, a rule or law always to be followed. Those who are responsible for this bulletin are in agreement, however, that principles of good planning exist and should be followed.

This bulletin has no ready-made answers for shop planning. Some formulas have been developed for estimating the number of classrooms and recommendable areas of shops. Some tables of summary of important factors follow. But they are not mathematical formulas designed to meet the needs of every community. They are tables and recommendations based on averages and therefore not designed for a specific situation. School buildings, on the other hand, need to be planned for specific situations existent and for situations predicted as accurately as possible.

TYPES OF INDUSTRIAL EDUCATION

The following definitions and discussions are intended for architects and others who are not familiar with problems of industrial education.

Vocational education

Vocational education is that portion of every person's total education which is primarily concerned with the development of employability.

Vocational-industrial education

Vocational-industrial education is that type of vocational education which is for advantageous entrance to, and advancement in, highly skilled trades.

Vocational-industrial education programs which qualify for federal aid require that the pupils spend at least 30 clock hours a week in school. "Each six-hour school day is divided as follows in respect to subjects of instruction:

General and related technical subjects.....180 minutes
Trade shopwork on a useful or productive basis.....180 minutes

The content and extent of the related or technical subjects in each trade and industrial field shall be based on needs as shown by an analysis of the occupation." (6:4)*

Administratively, this means that only two groups of pupils (two classes) can be housed in a vocational-industrial shop in a 6-hour day.

Vocational-technical education

Vocational-technical education is that type of vocational education which is for advantageous entrance to, and advancement in, technical occupations.

When skills are the dominant factor to be taught, the program is vocational-industrial education. When technical information is a factor of relatively greater importance and/or requires more time than teaching manipulative skills, the program is vocational-technical education.

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* The numbers in parentheses refer to the bibliography.

The scheduling of vocational-technical courses permits four groups of pupils a day in a given shop space. This is due to the fact that vocational-technical pupils are enrolled in shop courses for only 90 minutes per day.

Shop spaces recommended for vocational-industrial programs will be satisfactory for vocational-technical programs. Equipment for those spaces may be somewhat different. In any case, equipment specifications should be based on course of study analyses.

Adult education

Vocational-industrial shop courses are generally among the school's offerings in greatest demand for adult education programs. This fact has several implications for buildings. For example: to avoid unnecessary duplication of facilities, the equipment of shops should be selected in anticipation of the requirements of supplementary training for upgrading employed workers as well as of the needs for pre-employment training; separate control of the heating supplied for areas most likely to be used at night, from those least likely to be used, is highly desirable; corridor gates which limit access to certain areas of a building may be desirable; illumination in shops should be adequate for efficient operation without any daylight. Some of these factors will be discussed in detail later.

Industrial arts education

Industrial arts is not vocational education. It is general education along industrial lines. It is concerned with the needs of all pupils in school. Some industrial arts experiences should precede all vocational-industrial specialization. It is concerned with the development of an interest in shopwork and the consumer values which are learned in shops. It is concerned with guidance, helping boys and girls discover their interests, their abilities and their inabilities. Its other objectives include the development of avocational interests and an understanding of, and insight into, industry.

Although there are similarities between industrial arts education and vocational-industrial education, their basic differences are sufficiently great and of such importance as to make a separate treatment of their physical facilities desirable. For this reason, this bulletin is making no recommendations for industrial arts.

PLANNING PROCEDURES

The following steps should be taken in planning building facilities for vocational-industrial and vocational-technical education in order that they will be adequate for individual communities.

School officials' responsibilities:

If the school has a vocational director, the superintendent will probably assign the responsibility for these tasks to him. Teachers, supervisors and advisory committees should participate in this planning.

1 **Determine curricular areas to be taught.** This should involve occupational and community surveys. See New York State Bulletin 1284, Community Surveys for Vocational-Industrial Education (5) January 1945. See also School Building Projects: A Guide to Administrative Procedures (12) which is a 1950 bulletin of the Division of School Buildings and Grounds. It is recommended that local school officials discuss their vocational education problems with the Division of Industrial Education, State Education Department, Albany, before any plans are drawn.

2 **Estimate anticipated enrolments.** An estimate of potential enrolments (every pupil who might be interested) is but one factor. Another factor is the desirable enrolment limits based upon annual hiring of new employes in occupations to be taught.

3 **Determine number of shops to be needed.** For specific suggestions on this point, see table 2.

4 **Develop courses of study.** These should be topical outlines made from occupational analyses.

5 **Plan the equipment to be installed in each shop.** Use courses of study for determining equipment required.

6 **Determine shop sizes.** Sizes should be based on required equipment. This will necessitate layout of a scaled shop floor plan.

7 **Estimate auxiliary space needed.** See section on "Auxiliary Rooms and Facilities."

8 **Plan built-in equipment.** The architect should be advised as to the functions of built-in equipment and, in some cases, sketches should be furnished.

9 **Assist architect.** The vocational director or the person delegated by the superintendent should assist the architect by providing answers to all questions of detail regarding shop instructional activities.

GENERAL CONSIDERATIONS

Location of school sites

Factors concerned with the location of school sites are generally beyond the scope of this bulletin. It may be appropriate, however, to question the practice, existing in some places, of locating schools which teach vocational-industrial curriculums in dominantly industrial areas. This practice can not be justifed unless such a location best serves the needs of all pupils in the school.

Schools should be located central to their pupil population. In determining what constitutes being central, consideration should be given to transportation as well as geographic factors. Locations peripheral to population centers frequently may be justified. Advantages gained by a peripheral location may include availability of more campus space and cheaper land values which enable a given amount of money to purchase better physical education, recreation, and athletic facilities. In general, the location of a school away from crowded business and industrial areas is conducive to optimum learning.

For the accommodation of evening school programs one very important physical feature in site choice is that there must be adequate space and provision for the parking of cars. Experiences indicate that adults have not objected to peripheral locations but that lack of parking facilities has been a definite deterrent to attendance.

Location of shops in building wings

It is recommended that the location of shops in comprehensive high schools should be in separate wings of the building from classrooms for other school subjects. This suggestion is not made because of any intrinsic differences in pupil characteristics or differences in educative value of shop courses. The primary factor is

the basic differences in space requirements for adequately housing shop and classroom programs. Shop areas should be at least 30 feet in width and for some types of activities should be 40 feet or greater. Classroom widths of 22 or 23 feet are generally recommended. This desirable differential in room widths emphasizes the architectural practicability of placing shops in separate wings. The desirability of separating noisy school activities from quiet ones may also be a good reason for placing shops apart from classrooms for other school subjects.

Location of shops in separate building

If a school's campus is composed of several buildings, all types of shops should be located in one building rather than shop wings. When a separate building is planned for housing shops, care should be taken to make such a building an integral part of the total educational plant. Some school officials believe that separate shop buildings contribute to alienating vocational pupils from the rest of the school.

Relative location of shops

Relative location of shops in accordance with the nature of their basic activities is highly important. That is to say, when two or more closely related shops, for example, two machine shops, or an electric laboratory, an electric construction shop and a radio shop, are part of a school's program, it is desirable that they be adjacent to each other. Automotive mechanics is more closely related to aviation, welding, machine shop and electric equipment maintenance than it is to building trades, cabinetmaking or drafting and should be located accordingly. Industrial chemistry is more closely related to other science laboratories than it is to most vocational-industrial shop activities and should be located near the other chemistry laboratories.

Special classrooms

Special classrooms are not required for the general education subjects studied by vocational pupils. It is desirable that vocational pupils not be segregated from other pupils in English, social sciences etc.

Floor level locations of shops

Floor level preference for the location of shops is the first floor. It is especially important that "heavy" shops be so located. Automotive shops do work on "live" cars and therefore "drive-in"

accessibility is mandatory. The delivery of lumber and other bulky materials to woodworking shops makes driveway access highly desirable.

"Light" shops, such as drafting, beauty culture, power sewing machine operation and radio repair need not be on ground floor locations.

New school buildings should not be designed to house any instructional activity in basement spaces.

Elevators

Elevators for freight are needed in all multistoried school buildings. Such a service is especially important for "medium" or "heavy" shops located above the first floor. When a building is equipped with elevators, they should be located so that loading platforms with canopies are easily accessible for truck deliveries and pick-ups. Elevators should be located so that corridors provide access to all areas of each floor with a minimum of disturbance to classroom and shop activities.

Safety

No section of this bulletin has been specifically devoted to a discussion of safety. An effort has been made to consider safety factors in all recommendations. Shop Safety Education (7) presents an excellent discussion of safety problems and their administration. In its chapter on "Shop Layout," (7:31) primary considerations include: adequate pupil work space, aisle space, machine locations, isolation of hazardous jobs, location of switches and lighting.

SIZES, SHAPES AND NUMBER OF SHOPS

Sizes of shops

The sizes of shops will vary in accordance with the program planned for their utilization. No rule of thumb can be used in determining the size of a shop. The size should be determined on the analyses of the content of the courses to be taught, of the machines and equipment needed and a floor plan layout. The following suggestions of shop sizes are based upon averages for certain activities that have been found by experience to be satisfactory. These averages should be used only as a basis of checking the reasonableness of space allotments.

TABLE 1

Spaces recommended for open shop area in vocational-industrial and vocational-technical shops (20 pupils)

A. "Heavy" shops (For example: automotive, aviation, carpentry, cabinet-making and millwork or machine shop)

Shop	Square Feet Per Pupil	Square Feet Total Open Shop Area
Desirable	150	3000
Average	120	2400
Minimum	100	2000

B. "Medium" shops (For example: beauty culture, electricity, printing, or trade dressmaking)

Shop	Square Feet Per Pupil	Square Feet Total Open Shop Area
Desirable	120	2400
Average	90	1800
Minimum	75	1500

C. "Light" shops (For example: drafting, nursing or power sewing machine operation)

Shop	Square Feet Per Pupil	Square Feet Total Open Shop Area
Desirable	75	1500
Average	60	1200
Minimum	50	1000

These recommendations represent a compromise between what is existent in acceptable programs in New York State and what is desired by teachers and administrators. These are recommendations for comprehensive high schools in New York State in 1949. Other geographic areas and future years may result in the development of different recommendations.

No shop can be classified arbitrarily as being "heavy," "medium," or "light" without some knowledge of the content of the courses to be taught and the character of the equipment. For example, an electric laboratory, involving the generation of power, might be a "heavy" shop; electric construction might require a "medium" shop; while radio work might necessitate only a "light" shop.

Shapes of shops

The shape of shops is important. Any shape which does not allow an instructor visibility of the entire area at all times should be avoided. The shape of shops should range from square to a ratio of length to width of not more than two to one. In terms of shop sizes this means that a shop of 2400 square feet might be 40 feet by 60 feet, a shop 1200 square feet might be 30 feet by 40 feet and one 3000 square feet might be 50 feet by 60 feet.

A bowling alley-shaped shop is virtually impossible to lay out for effective operation and safety. There is a definite trend toward shops which are nearly square because they permit effective equipment layouts and efficient space utilization.

Ceiling heights

Ceiling heights should vary according to the character of the shop and the work carried on. The minimum is 11 feet. For aviation shops the minimum is 12 feet; for many shops 14 feet is desirable. A foundry should have a ceiling height of approximately 30 feet. Consideration should be given to the need for 24-foot heights for areas of shops in which some types of building trades activities are conducted.

Mezzanines

Mezzanines, or balconies, in shops are not generally desirable. If such are planned they should be used only for storage and easy accessibility to them should be provided. Stairways leading to them should not have excessive rise.

Pupil-teacher ratios

In general, 20 pupils per teacher should be considered maximum desirable load for shop or laboratory courses in vocational-industrial or vocational-technical education.

Determining the number of shops

The following table of recommendations relative to the number of vocational-industrial shops for comprehensive high schools are based on the assumption that shops will be planned to accommodate 20 pupils per teacher, that only one teacher will occupy a shop at one time, and that two three-hour classes a day will be held in a shop. Thus 40 day-school pupils per shop can be accommodated in a six-hour school day.

It is not recommended that a shop be designed to accommodate 40 to 60 pupils with two or three teachers. The floor space for which each teacher is responsible should be separated from adjacent spaces by full partitions.

TABLE 2

Recommended number of vocational-industrial shops for a comprehensive high school

TOTAL SCHOOL ENROLMENT	PER CENT OF TOTAL ENROLMENT EXPECTED TO BE IN VOCATIONAL-INDUSTRIAL CURRICULUMS							
	5%	10%	20%	25%	30%	40%	50%	60%
	TOTAL NUMBER OF SHOPS							
300	1	1	2	2	3	3	5	5
500	1	1 or 2	3	3	4	5	7	8
1000	1 or 2	3	5	7	8	10	13	15
1500	2	4	8	10	12	15	19	23
2000	3	5	10	13	15	20	25	30
2500	3	7	13	16	19	25	32	38
3000	4	8	15	19	23	30	38	45

NOTE. Assuming that only one teacher will teach in any shop at any one time and that one shop will accommodate two classes of 20 each a day:

$$\text{Number of shops} = \frac{\text{vocational-industrial enrolment}}{40}$$

Sample Interpretation:

In a comprehensive high school having an enrolment of 1500 pupils (col. 1, row 4), when 25 per cent of the total school enrolment (col. 5) is majoring in vocational-industrial curriculums, 10 shops (col. 5, row 4) will be required.

Table 2 should never be used as the only basis for determining the number of shops needed by a school. This should be done by an analysis of training needs as determined by a community survey of employment, employment practices, labor availability, labor-employer-school relations, and other pertinent factors. It is intended to serve only as a check on the adequacy of plans. It considers only enrolment potentials. More than the number of shops suggested by Table 2 may sometimes be justified. For example: training needs may

justify establishing or continuing a shop when enrolment in that curricular area is less than 40 pupils. In such cases the basic assumption in the design of the table, that a shop cares for 40 pupils, is fallacious and the recommended number of shops will be too low to care for the vocational education needs in that school.

No attempt has been made in this table to allow for an adult-education day school shop program. Instead, it is suggested that shops needed for day school should be adequate in size and should be adequately equipped to care for adults in night school programs. When adult education needs are sufficiently different from those cared for by day school shops as to demand different types of physical facilities, plans should be made accordingly for additional shops.

FLEXIBILITY

In the study of schools referred to in the preface, one feature of building planning on which there was unanimity among school administrators was a desire for maximum flexibility in school construction. Some administrators have expressed the opinion that rigidity of construction has been a deterrent to needed curricular changes.

Partitions

One of the prime factors of flexibility is the type of partitions which are used in school buildings. Full partitions, extending to the ceiling, are recommended for dividing floor space between areas occupied by different teachers. Partial partitions may sometimes be justified for dividing floor space within a shop area. Partitions should be nonload-bearing in so far as possible. Cross-partitions should be movable with relatively little disturbance to a building structure in order to permit a rearrangement of floor spaces when required. Steel partitions, with and without sections containing glass windows, have been found highly satisfactory.

Fenestration

The fenestration of a building affects its flexibility by making it either practicable or difficult to move cross-partitions. Continuous, industrial type windows are recommended. They should be designed on a module which permits partitions to be moved. Such a plan of window construction would permit partitions to be placed between

module units without disturbing the outside appearance of a building. Shops arranged in a line could then be readjusted in length as desired. Shifting of partitions and the resultant transfer of floor space from one shop to another should help care for fluctuations in enrolment and for differentials in floor space requirements by different curricular areas.

Electric services

Electric wiring and other services should not be installed in cross-partitions. Electric outlets on cross-walls should be supplied through conduits or metal molding placed on the face of the walls in order to facilitate the movement of partitions when desired.

Electric power

Electric power supplied to machines in shops and laboratories through overhead ducts contributes to flexibility. If power supply lines are to be installed in the floors of shops, it is recommended that fiber ducts or Q-type floors be given consideration. (A Q-type floor is a cellular hollow-steel construction providing a series of raceways for electric wiring.)

Electric lighting circuits

Circuits should be so planned that lights of any given shop areas are controlled within that shop. Areas of control should be small and should parallel windows so that the lights on the dark side of the room are separately controlled from the lights nearest the windows.

LAYOUT OF FLOOR SPACE

Spacing of equipment

The best approach to this problem is to have experienced teachers plan the location of all equipment in accordance with its function in the teaching process. The following generalizations can be made:

1 Machines and other equipment should be arranged in accordance with operations to be taught and placed in proper relation to other equipment. For example, in a woodworking shop the location of lumber storage will determine the placement of certain machines.

2 Cleaning of floors around machines is made easier if a clear space exists through 360 degrees around each machine but the space required to do this is not always justified.

3 When machines are placed back to back in order to save floor space, care should be taken that such an arrangement does not interfere with their operation.

4 Crowding of machines is never justified if it makes the shop less safe for pupils.

5 The placement of machines, for which daylight is highly desirable, at an oblique angle to windows is frequently justified but may require more floor space than other types of arrangement.

6 Aisle widths of three feet should be considered minimum. Major traffic aisles should not be less than four feet.

7 The painting of aisle lines and of machine zones on the shop floors is an effective contribution to safety.

Open floor space

Some open floor space is highly desirable in most shops. In automotive shops work is done on "live" cars; it is therefore recommended that at least 50 per cent of the floor space should be open. Where tool cribs in shops are to be used, clearance of floor space from the tool crib window should not be less than six feet. Advanced carpentry shops should have approximately 50 per cent of their floor space without benches or machines. In cabinet shops adequate space should be available for assembly.

Doorways

Doorways for outside access to shops, such as automotive and building trades, should generally be 10 or 12 feet wide and 10 feet high and of an overhead type. If pupil access is frequently to be gained from outside the building, a three-foot door in the outside wall should be provided. Such doors should be equipped with panic bolt hardware. A floor plan of each shop's utilization should determine door locations. It is generally recommended that automotive shops have at least two large overhead doors adjacent to each other on the long side of the shop and located approximately seven feet from one end of the shop. One general rule is that doors shall never be in the corner of a room but shall be far enough away from a per-

pendicular wall to permit maximum utilization of all wall space. The recommended minimum distance of any door from a perpendicular wall, which might be used for a bench location, is seven feet.

In addition to floor space utilization, the number and location of doorways should provide for adequate means of escape in case of an emergency. Large shops should have at least two exits sufficiently removed from each other so as to assure availability of one of them at any time.

Storerooms for lumber and other heavy supplies should have access directly from driveways and should be equipped with doors suitable for the admission of the types of materials to be received. This may mean six-foot wide double doors or doors of an overhead type.

Doors from corridors into shop areas will be dependent upon other access to a shop area. If the shop is accessible directly to the outside of the building with large doors for deliveries, then single three-foot corridor doors are generally adequate. When a shop has no accessibility other than through a corridor, it will need to have a six-foot wide double door.

Location of benches

This is a problem which should, where practicable, be left to the discretion of the teacher who is going to occupy a given shop. Where it is desirable to locate benches in such a position as to secure maximum daylight, their location with their long axes perpendicular to windows will usually provide a better light than their location parallel to windows. If, in order to save floor space, benches are placed parallel to walls, attention is directed to the importance of studying the need for special lighting over them. This need exists for benches which are under windows as well as benches arranged along blank walls.

Lecture-planning areas

Lecture-planning areas in shops are not recommended unless part-time use of an adjacent classroom is not available. Some shops will not need either a lecture-planning area or an adjacent classroom. This negative recommendation is made because of the limited use of such a space in a well-managed shop.

Projection aids area

Recent developments in the production and distribution of audio-visual aids projection materials now make it desirable that a projec-

tion aids area be provided in many shops. The provision of such an arrangement would be for the instruction of small groups of pupils and would not take the place of audio-visual rooms which can be darkened for the showing of visual aids to entire classes or larger groups. This projection aids area can be provided in any section of the shop which is relatively dark and has as much as nine square feet of blank wall space at a height suitable for a projection screen. Modern projection equipment can be used satisfactorily with a properly painted wall as a screen; a roll-away beaded screen, however, is more satisfactory.

Shop storage

It is of vital importance that every shop be provided with adequate storage space. The planning of all storage, including supplies, tools and projects, must precede the layout of shops.

In all shops, full advantage should be taken of storage space available under shop benches. When such space is fully utilized, by built-in shelves, cabinets or drawers, attention should be given to toe space being provided under the working edge of every bench. If a bench top does not extend at least four inches beyond the base of the bench, a toe space four inches deep and six inches high is recommended. For ease in cleaning, all cabinets should extend to the floor.

If movable storage cabinets are favored for the type of instructional materials involved, an analysis of the storage problem should be made to determine the number and types of cabinets needed. Adequate wall space should be anticipated for their location.

Tool storage panels

Panels for tools, located in areas of a shop where those particular tools are most used, are recommended. For example, it has been found to be practicable to have the tools most frequently used in the operation of an engine lathe mounted on a tool-outlined, open panel board immediately adjacent to the lathe. Tools used most frequently at benchwork stations should be stored on panel boards very near to those benches. An identifying color scheme may be used to mark tools that belong to each panel board in the shop.

When security of tools is an item of major concern, it is suggested that panel cabinets be designed of a type which can be locked when tools are not being used. Such cabinets with insides of doors serving as tool panels have been found practicable.

Chalkboards

It is recommended that a minimum of 36 square feet of chalkboard space should be provided in each shop. Consideration of a board more highly reflective than slate blackboard is recommended. Dark green colored chalkboards are being found very satisfactory. When 36 square feet of chalkboard is inadequate, it is suggested that vertical sliding panels or book-type chalkboards be considered.

Bulletin boards

Bulletin boards should be provided in all shops. It is suggested that a minimum of 32 square feet of tack board be provided. One preferred location for such display space is adjacent to exit doors to corridors. Consideration should be given to providing adequate light on all display board space. Additional bulletin board space may be provided by mounting tack boards on cabinet doors. For some types of displays, book-type display panels, vertically hinged in an effective location, are very satisfactory.

SERVICES IN SHOPS

Electric outlets

Double convenience electric outlets for 110-volt current should be located at eight-foot intervals on all shop walls. These outlets generally should be at a height of 48 inches in order that electric appliances can be plugged in above bench height. Safety factors affect the location of outlets. For example, safety demands that outlets should not be placed in the immediate vicinity of wash basins.

Power capacity

Electric power capacity in shops can be recommended only in terms of the utilization planned for specific spaces. Anticipated power capacity should be calculated by estimating the maximum instantaneous load for every shop.

"Heavy" shops should be wired for 220-volt, three-phase current and, for the sake of flexibility, wired to care for a peak load of at least 40 kilowatts. This will necessitate 100-amphere service to the panel board of all "heavy" shops. A few shops, electric welding for example, will require greater capacity.

Current capacity anticipated for all shops should take into consideration the connected load and the diversity factor. It is highly

desirable in an electric laboratory that lines be sufficiently heavy to provide for a very small voltage drop. Electric laboratories should have a DC generator or rectifier capable of producing at least 15 kilowatts of direct current.

Electric current for "medium" shops may sometimes be only 110-volt service, but flexibility of curricular assignments to shop areas will be increased if 220-volt service is available to all shops. "Medium" shops should be provided with 25 kilowatts. In the case of an electric machine laboratory, at least 40-kilowatt capacity should be provided even though the shop might be housed in a "medium" unit of floor space.

The service for most "light" shops should be 220-110 volts, single-phase three-wire. Some "light" shops, radio for example, may require equipment which operates most efficiently on 220-volt, three-phase current.

Electric control panels

The control panel for the electric light and power of each shop should be located in the shop on the corridor wall. The panel should be mounted flush with the wall and equipped with a door which can be locked. This panel should be of a remote control type, with a red pilot light. Control buttons, for the master switch, should be provided at at least two points within each shop. Location of these "off" buttons should be planned at points most conveniently reached by the instructor. In order to assure maximum safety in the operation of the shop, as many individual circuits should be provided as feasible, preferably one for each major item of power equipment.

In the case of electric laboratories, switchboards should be near the center of corridor walls in order to reduce installation costs and to minimize voltage drop.

Gas

Gas used for heating units will not be required in all shops. For those shop activities in which gas heat is needed, anticipated capacities will vary greatly. Some shops may require only a one-half inch line, while others, with large gas ovens or furnaces, may need service requiring a two-inch line. It is suggested that a computation be made of estimated demand requirements of equipment anticipated.

Water

Hot and cold water should be available in all shops. (*See* "Washrooms" in section on "Auxiliary Rooms and Facilities.")

In those shops where water is an instructional material, an analysis should be made of the conditions under which it is used and an estimate made of volume needed. Such an analysis is necessary in order to determine types of sinks needed, desirable sink locations and sizes of service lines needed.

Drinking fountain

A drinking fountain should be provided in every shop. Although it should be located near the wash-up sink, it is recommended that it be a separate unit rather than a combination fixture.

Compressed air

Compressed air should be accessible to all shops. Centrally located compressors have generally been found more satisfactory than individual compressors. Since compressed air may not be needed by all shops, it is suggested that air lines be provided from the compressor to all shops and that the service be tapped only when its use is anticipated.

Fire extinguisher

Some type of fire extinguisher should be provided for every shop. Building planning should anticipate the type of extinguisher to be used and provide a space for its installation. A recessed wall area is the most satisfactory location.

AUXILIARY ROOMS AND FACILITIES

All shop programs require some auxiliary rooms. These should be planned at the same time as the rest of the shop. The number and kind of auxiliary spaces depend on the nature of the instructional materials and activities. They should include: offices, related subjects classrooms, projection-aids facilities, related science laboratories, toolrooms, supply storage rooms, finishing rooms, locker rooms, toilets and washrooms.

Offices

Offices for vocational directors and supervisors should be located central to the activities of the shops. They should also be convenient to building entrances accessible to the public.

Related subjects classrooms

The classrooms used for teaching related subjects should be conveniently located with respect to the shops. A study of the total program needs to be made in order to determine the number of such rooms required to provide for shop theory and related subjects. When not needed for vocational subjects these rooms can be used for other classes. Double convenience outlets should be provided in front and rear walls. Such rooms should be adequately equipped for darkening sufficiently to show any common projection aids including opaque materials.

Related science laboratories

In small comprehensive high schools, the science rooms used for general science or physics and chemistry may be planned to meet the needs of related science, provided attention is given to such needs in the selection of equipment.

In any school building which provides four or more vocational shops, it is suggested that at least one room should be specifically planned for a related science laboratory. If such a laboratory is not used full time for related science it can be utilized by other science classes. The related science laboratory might well be located as part of the science suite. (11)

Toolrooms

Toolrooms, so designed as to require a full-time attendant for issuance and security of tools, are not recommended. It is doubted that the practice of using the toolroom as one training station in a school shop can be justified. When toolrooms are planned, their location should be such as to minimize pupil travel to and from work stations. The location of the toolroom is a factor which should be given careful consideration in shop layout. The use of panel boards in toolrooms is preferred to keeping tools in drawers.

Minimizing the use of toolrooms can be accomplished by the use of tool storage panels in open shop areas. (*See* "Tool Storage Panels" in section on "Layout of floor space.")

When the character of shop equipment is such as to require particular care (for example, meters and other delicate instruments for an electric shop), special storage and issuance rooms should be provided.

Supply storage

One of the most frequently neglected factors in shop planning is adequate provision for storage. Storage space requirements vary so greatly in accordance with the nature of the shop's activities and materials of instruction that no specific recommendation of amount of space is being made. In general, metal trades require less cubage for storage than do woodworking trades or upholstery.

It is recommended that adequate central storage be provided to care for some of the materials of all shops. If this is done, no auxiliary storage will be needed for some individual shops as cabinets within the floor space of certain shops can accommodate all needs.

Supplies immediately available for issuance to students should usually be kept separated from reserve supplies. The former may be kept within the shop area; the latter should be kept in an auxiliary room.

Some analyses of storage facilities indicate that, for a diversified shop program adequate storage requires auxiliary floor space totaling approximately 10 per cent of the total floor space of all shops.

The one unalterable recommendation regarding storage is that details of such spaces should be designed for the type of materials to be stored and space required should be determined by an analysis of the materials of instruction for each shop. Such space should be properly located in respect to receiving materials and dispensing them to shops.

If an extensive night school program is operated using the same shops and equipment as the day school program, it is desirable to provide separate supply storage. This is especially important if accounting procedures, purchasing, and issuance of supplies require a separation of day school and night school records.

Lockers

Individual lockers, adequate in size for personal shop tools, books and shop clothes should be provided for every pupil including those in evening classes. Locker rooms are not recommended. Lockers should preferably be located in the shop areas, in alcoves which permit supervision by the teacher. In some shops these lockers will be adequate for partially completed trainee work.

Project and product storage

In vocational shops pupils do work on a useful or productive basis. Such pupil work, while in the process of completion, may require

storage. Only by an analysis of course of study outlines and an estimate of the size, shape and number of projects likely to require storage at any one time can adequate storage space be planned. In some instances, an auxiliary room may be required.

Finishing rooms

In connection with cabinetmaking and millwork a finishing room is actually a part of the shop. It is discussed as an auxiliary room because the problems of finishing are such as to require that it be separated from other areas. Such a room should be dustproof. An independent exhaust system is recommended. Special attention is called to the need of high levels of illumination on vertical as well as horizontal surfaces.

Spray booths require special lighting and ventilation. They are required in such shops as painting and decorating, cabinetmaking, and automotive body shops.

Toilets

Toilet facilities should be located so that they are easily accessible to pupils in shops.

Washrooms

Clean-up washing facilities should provide at least four lavatories for each shop. More than four lavatories may be needed in foundries and other shops where the nature of the work results in pupils being especially dirty at the end of the shop periods.

Washrooms separated from the shop are not recommended. The use of wash-up facilities in locker alcoves is difficult to supervise in that their major use comes at a time when an instructor has numerous other responsibilities. It is suggested that fixtures be located along shop walls so that clean-up activities can be kept in sight by the teacher from any point in the shop.

Sinks of rectangular or a half-circular type are considered satisfactory. Sinks in open areas, permitting 360-degree accessibility, may be satisfactory but require considerable space. Hot and cold water mixing type faucets are recommended.

Display centers

Every school should be provided with in-the-wall, shelved and lighted display cabinets for pupils' work and other materials of general interest. Since such displays are a part of good public rela-

tions, it is suggested that some of them be located in foyers and main corridors. Locating such display cases near the school's trophy case is contributive to their receiving attention. Shelves should be adjustable and removable.

Where practicable, access to display cases should be from the back. Proper lighting is important.

Display cases in corridors near shops and in certain shops can be very effectively used.

Corridor gates

In order to limit the accessibility to certain sections of school buildings, corridor gates are frequently desirable. Locations of such gates should be anticipated in order that corridor walls can be designed with necessary recessed areas. One very satisfactory gate is an overhead roll-away type which can be pulled down to the floor when needed and key-locked into its closed position.

FLOORS

Floor loads

Attention is called to the fact that some shops have equipment which will constitute heavy concentrated loads. Anticipated equipment for shops should be planned before shop floors are designed. Not only must heavy equipment be moved to its intended location but the flexibility of a school's program, from year to year, may make it desirable to place heavy items of equipment in locations not anticipated at the time of building construction. Operation of some equipment may cause vibration problems which affect floor loads. These factors should be given consideration in the design of the building.

Machinery mounting

Types of machines used in shops of comprehensive high schools are usually not heavy enough to involve serious mounting problems. In Diesel engine shops and for some machines in printing shops, attention is invited to the problem of vibration. Some machines may need to be mounted on special bases with vibration-absorbing pads. Certain items of equipment need to be anchored into the basic floor structure through the finished floor. Sometimes it will be desirable to design and construct machine mountings independent of finished floors and before the finished flooring is laid.

Shop floors

Factors to be considered in choosing shop floors include: (1) wearing qualities of floor material; (2) cleaning ease of material; (3) maintenance in service; (4) use of acids and solvents and the resulting need for impervious materials; and (5) extent and type of personnel and material movement on the shop floor.

Table 3 shows recommended materials for shop floors.

Concrete is the most frequently used shop floor. It is satisfactory in most shop areas and preferred material for a few. The chief objection to concrete is its lack of resilience, its tendency to dust and its relatively high porosity which makes it difficult to clean thoroughly. When concrete floors are desired, care should be taken to have specifications written so as to secure a smooth, nondusting, finished surface. Hardener topping for concrete is available in a variety of colors within a recommendable range of reflection factors. This topping is an integral part of the concrete floor, has a very low porosity and takes a nondusting finish. It is much harder and cleans better than other concrete finishes.

End-grain wood block floors, laid on a mastic base over concrete with provision made for expansion, have been found very satisfactory in some places. Some of them have the objectionable feature of being very dark. If used where metal filings or chips fall onto them, they impregnate rather easily. They can not be satisfactorily washed. End-grain wood block floors are available in natural wood finishes.

Asphalt tiles now on the market are worthy of consideration provided their limitations, as well as their advantages, are studied in relation to each shop's activities. Plastic tile floor coverings have qualities worthy of investigation.

TABLE 3

Recommended shop floors

NOTE. Types of floor rated "1" are considered first choice. Those rated "S" are considered to be satisfactory.

SOME VOCATIONAL-INDUSTRIAL AND VOCATIONAL-TECHNICAL SHOPS	TYPES OF FLOORING					
	MAPLE	END-GRAIN WOOD BLOCK	CONCRETE	ASPHALT TILE	LINOLEUM	OTHER
Auto mechanics	..	..	1	..	..	..
Aviation	..	..	1	..	..	..
Baking and cooking	S	..	..	S	..	1 Terrazzo or quarry tile
Beauty culture	S	..	..	S	1	..
Brick laying	..	..	1	..	..	..
Cabinetmaking and millwork.	1	S	..	..	..	..
Carpentry	S	1*1	..	..	..	..
Drafting	S	..	..	S	S	..
Electricity	S	1	S	..	..	..
Foundry	..	..	1*2			S Dirt
Machine shop	S	1	S	..	..	..
Painting and decorating	S	1	S	..	..	..
Patternmaking, wood or metal	1	S		..	..	..
Power sewing machine	S	..	..	S	1	S Rubber tile
Printing	1	S	S	..	S	..
Radio	S	S	..	S	1	..
Refrigeration servicing	S	1	S	..	..	..
Science, related	S	..	..	1	S	..
Sheet metal	1	S	S	..	..	..
Tailoring	S	..	..	S	1	S Rubber tile
Upholstering	1	S	S	..	..	..
Welding	..	..	1	..	..	..

*1 "Construction" area of shop to be floored with two-inch tongue and grooved fir or similar material.

*2 Portion of shop space used for molding and furnaces to be dirt floor.

Abrasive floor areas

Areas of a shop floor where machine operators stand while at work should have an abrasive surface. The size and location of such areas will be dependent upon the nature of the foot movements required by the operators. Example: A variety saw or jointer in a

cabinet shop should have such an area. Materials found suitable for this include an a rasive, nonskid substance that can be painted or troweled onto any floor or ribbed rubber mats cemented to the floor.

Floor drains

In every shop where the instructional activity is of such a nature as to make it desirable to clean the floors by scrubbing them, floor drains may be desirable. Automotive shops always need drains. It is suggested that drains be located approximately ten feet from the outside doors. Since much of the maintenance work done on cars requires smooth level floors, the slope of floors toward drains should be very slight.

ACOUSTICS IN SHOPS

Smoothly finished, easily cleaned wall and ceiling surfaces, such as are desirable for shops, contribute to poor acoustical conditions. Such factors indicate the desirability of acoustical treatment.

Segregation of shops from other school activities frequently is justified, in part, because shopwork is a noisy activity. Since noise in schools is objectionable, it seems logical to control it at its source and to use acoustical treatment where practicable. The experience of industrial organizations indicates that worker productivity, morale and efficiency are appreciably influenced by noise.

Only if it is necessary economy, should shops be constructed without acoustical treatment. The counsel of an acoustical engineer is recommended. The possibility that acoustical treatment of ceilings may be cheaper than finishing and painting the underneath side of floor slabs should be investigated.

Isolation of shops will reduce the noise transmitted to other school areas. Only noise control and absorption can help to make them quieter. Motors may be mounted on sound-insulating bases (4:160); flexible connections should be used to reduce transmission of sound through ducts; and, in some instances, segregated positive ventilating facilities should be provided for noisy units so that they may be used without opening windows and increasing the transfer of sounds to other rooms. Best results in applying sound-absorbing materials "are obtained when such materials are applied according to acoustical engineering patterns." (4:160)

SEEING WITH COMFORT AND EFFICIENCY

Attention is invited to Visual Comfort and Efficiency in School Buildings (13), published by the Division of School Buildings and Grounds in 1947. It is the intent of this discussion merely to direct attention to some factors of lighting that apply to school shops which may not apply in the lighting of other areas of school buildings.

The emphasis is not on how much illumination is needed but rather on how well pupils can see. This focuses attention on the importance of creating a balanced brightness which will produce visual efficiency and comfort.

Unique features of shops which make their lighting problem different include: floor spaces wider than usual classroom widths; pupil work stations facing many different directions in the shop; and visual tasks of multitudinous degrees of difficulty including many tasks on angular and vertical surfaces.

Daylight sources

As important as daylight is in providing comfort and ease in seeing, its maximum utilization in most school shops may have to be sacrificed in favor of other factors. One-fourth or more of the occupied time of many shops is at night. Floor areas of 2000 square feet and more are desirable with shop widths of 30 feet or more. With unilateral lighting, such widths preclude the practical achievement of the usual daylight requirements.

Multilateral daylighting is practicable for many shops if attention is given to the problem of eliminating shadows and to maintaining a balanced brightness. The very nature of instructional activities in shops is such that pupils are not limited to specifically assigned positions all facing one direction.

Conventional skylights are not generally recommended.

The use of clerestory windows is encouraged on one side of bilaterally daylighted floor spaces.

In case elaborate or expensive schemes of daylighting are contemplated, it is suggested that their merit be evaluated with full cognizance of the fact that, no matter how well shops are daylighted, artificial illumination will need to be adequate for efficient seeing in evening vocational classes.

Daylight shading and deflection

The problem of shading visual tasks from direct sunlight is no less important in shops than in classrooms. This is somewhat more

difficult because air-laden dust is frequently more prevalent in shop areas and discourages the use of venetian blinds and pull-shades.

Deflection of daylight to ceilings has proven an effective means of increasing the amount of illumination which reaches the side of a room farthest from windows. The need for floor widths of 40 feet or more makes deflection more important in shop lighting than in classroom lighting.

The two factors of shading needs and deflection needs combine to suggest the consideration of directional glass block for outside shop walls.

Window sill heights

It is suggested that the height of window sills in shops should approximate 48 inches. The height of classroom sills should be at desk level.

The top light from windows contributes most to daylighting interiors. The glass should extend as near to the ceiling as practicable.

Levels of illumination

One dominant factor which has been mentioned earlier is repeated for the sake of emphasis. Artificial illumination in all shops should be adequate for effective and comfortable vision at night.

It must be emphasized that the important consideration in shop illumination is that recommended foot-candle levels be maintained in service and that the illumination desired must be on the work. Cognizance should be taken of the fact that such tasks as reading the 64th inch graduations on a scale or reading the micrometer are not visual tasks to be performed on a horizontal surface at bench height. Such visual tasks must frequently be performed with precision measuring instruments on a vertical plane.

This section is making no attempt to analyze the visual problems of shopwork. The purpose here is to point out the need for the analysis of visual problems before planning the lighting desirable for any given shop activity.

It will be noted that Table 4 contains recommended initial and maintained levels of illumination. The maintained level is the one which is important. All types of electric lamps lose some of their initial intensities rather rapidly at first. The maintained level of illumination approximates three-fourths of the initial level. This means that initial installations should be one-third higher than recommended maintained levels.

TABLE 4

Recommended levels of illumination

LOCATION	MINIMUM MAINTAINED FOOT-CANDLES OF GENERAL ILLUMINATION	MINIMUM INITIAL FOOT-CANDLES OF GENERAL ILLUMINATION
Shops, laboratories—on the work[1]..	20	27
Classrooms—on desks, tables, chalk and display boards	20	27
Offices—on desks	20	27
Sewing rooms, drafting rooms, art rooms, and other rooms where fine detail work is to be done—on the work	30	40
Locker rooms and toilets.....	10	13
Storage rooms	10	13

[1] Special attention should be given to the illumination of critical visual tasks on vertical surfaces.

Glare

"Glare is defined as any brightness within the field of vision, of such character as to cause discomfort, annoyance, interference with vision, or eye fatigue." (14:10) There is particular need for an analysis of the problems of glare in lighting shops.

Special lighting required to bring recommended levels of illumination to the location of some critical visual tasks creates brightness differences of such a nature as to necessitate careful shading of these local sources. For example, the visual tasks involved in performing precision work on a machine may demand localized illumination. In providing such supplementary light, care must be taken to shade the bulb from the visual field of all workers in that vicinity.

Recommended reflectances and colors

The problem of how much light can be secured on the work from any given source is very closely allied with color and light reflection. Attention should be given to the selection of a highly reflective, diffusing paint for those parts of machines which could be used to reflect light on critical visual tasks.

If surfaces surrounding the graduations on scales or dials on certain machines are painted with a highly reflective paint the graduations are much more easily read than when these same machines are

painted with a dark color. For example, the universal milling machine has graduations under its table that enable its operator to make a direct reading of the angle at which the work is being set in relation to the milling cutter. This dial is shaded from the overhead general illumination by the table and the saddle of the milling machine. In shops with adequate general illumination this visual task may be sufficiently illuminated if the surrounding areas of the machine are finished with a paint having a high reflection factor.

HEATING AND VENTILATING

Attention is directed to Heating and Ventilating Recommendations for New York State Schools (6) which was developed by a committee and consultants and was published by the State Education Department in 1946. This section will discuss only problems which apply to shops and laboratories.

Zoning

The prevalence of night school programs in vocational-industrial and vocational-technical education make it desirable that the control of heat in the shop wing of a building be designed and located so as to permit heating it independently of the rest of the building.

Special heating problems

In automotive repair and maintenance shops and other shops where pupils frequently work on the floors, the desirability of radiant floor panel heating should be investigated. A combination of floor panel heating and the use of suspended unit heaters may be practicable. The design operative temperature should be 68 degrees at 60 inches above the floor.

Regulations of the Commissioner of Education provide that:

" Maximum air temperature gradient from floor to 60 inches above floor shall not exceed 5° and preferably shall not exceed 3°.

" Air movement in zones of occupancy shall not exceed 25 linear feet per minute." (8:41)

Ventilation

The general problem of ventilating shops is comparable to ventilating other areas. In addition, special ventilating problems occur in several shops and special equipment will be needed to exhaust noxious odors, dust, fumes and gases.

Specific areas which may require exhaust hoods include heat-treating furnaces, welding booths and tables, paint spray booths, joint-wiping areas of plumbing shops and titration cabinets of chemistry laboratories.

The collection and disposal of the dust produced by grinding equipment in machine shops is a special problem that must be considered. Grinders should be grouped on the shop floor. Some grinders have attachments for collecting their dust. In the event they are not so equipped, provision should be made for a unit system.

In cabinetmaking and millwork installations, all major woodworking equipment may need to be supplied with dust and shaving collectors operated by a suction system. This is expensive equipment and its need should be justified. Some provision must be made for sawdust and shaving disposal in all woodworking shops.

In every shop where internal combustion engines are run, special ventilation must be adequate for removing carbon monoxide gas. Such ventilation systems must be completely separated from those serving other parts of the building. Flexible tubes will need to be provided from engine exhausts to overhead or under-floor ducts.

BIBLIOGRAPHY

1 **American Association of School Administrators.** American school buildings. 27th Yearbook. The association. Washington, D.C. 1949

2 **American Standards Association.** American standard practice for school lighting. New York. The association. 1948

3 **California State Department of Education. Bureau of Trade and Industrial Education.** Shop Planning Committee. Suggested guide for the housing and layout of school shops. 1948. mimeo

4 **National Council on Schoolhouse Construction.** Guide for the planning of school plants. The council; available from W. D. McClurkin, Peabody College, Nashville, Tenn. 1948

5 **New York State Education Department.** Community surveys for vocational-industrial education. Bul. 1284. Albany. Univ. of the State of New York. 1948

6 ———— Day and evening industrial education. Handbook 47. Albany. Univ. of the State of New York. 1949

7 ———— **Bureau of Vocational Curriculum Development.** Shop safety education. Albany. Univ. of the State of New York. 1949

8 ———— **Division of School Buildings and Grounds.** Heating and ventilating recommendations for New York State schools. Albany. Univ. of the State of New York. 1948

9 ———— Housing the audio-visual program. Albany. Univ. of the State of New York. 1948

10 ———— Planning the agricultural and industrial arts shops for central rural schools. Albany. Univ. of the State of New York. 1948

11 ———— Planning the science facilities for central schools. Albany. Univ. of the State of New York. 1950

12 ———— School building projects; a guide to administrative procedures. Albany. Univ. of the State of New York. 1950

13 ———— Visual comfort and efficiency in school buildings. Albany. Univ. of the State of New York. 1947

14 **Vocational Education Conference on Public School Automotive Instruction.** Recommendations on school facilities, equipment and supplies. Detroit. 1948. mimeo